NORTH CAROLINA
MARITIME Strategy

NC Maritime Strategy
Vessel Size vs. Cost

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by

AECOM
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EXECUTIVE SUMMARY

The trend in the container shipping industry in recent decades has been toward the use of increasingly larger vessels in order to maximize cost-effectiveness of moves through major trade lanes. This trend is driven both by economies of scale and the availability of infrastructure to these larger ships – such as the expansion of the Panama Canal to accommodate Post Panamax and Neo Panamax vessels. This memo examines the differences in cost expected between shipping in current Panamax vessels with an approximate capacity of 4,000 TEU and the post-expansion Panamax vessel size, Neo Panamax (NPX), with a capacity up to 12,000 TEU.

The objective of this memorandum is to illustrate where economies of scale will encourage ocean carriers to deploy larger containerships.

An evaluation of vessel operational costs, including fuel and crew costs as well as canal tolls, indicates that a 12,000 TEU vessel carrying about 51 percent of its total container capacity would have the same per-TEU operating costs as a Panamax 4,000 TEU Panamax vessel that is 80 percent full. Before putting the larger NPX vessels into service, shipping lines will need to be confident that they can achieve at least this level of utilization. Of course there are many options for vessels in between these sizes.

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1 INTRODUCTION

There are four primary cost categories to be considered in the operation of a large containership: initial capital cost (i.e. purchasing a new vessel), fuel, crew, and canal tolls.

For the purpose of determining container volumes at which point ocean carriers might deploy larger vessels all-water TransPacific routes to the US east coast, the relative costs of the following two representative containerships were evaluated:

- 4,000 TEU Panamax
- 12,000 TEU Neo Panamax

It is important to note that the various "Panamax" classifications represent a "typical" vessel that could navigate the canal. Not all 12,000 TEU vessels will be able to navigate the expanded Panama Canal and there are many ships in between the representative capacities discussed in this memorandum.

2 CAPITAL COST

Table 1 compares the cost of purchasing 4,000 TEU Panamax vessel and a 12,000 TEU Neo Panamax vessel, based on recent vessel purchases reported in the Journal of Commerce (see http://www.joc.com/maritime/oocl-mulls-super-sized-containership-order and http://www.joc.com/maritime/hamburg-sud-orders-six-9600-teu-ships). Capital costs are annualized over an estimated 30-year useful life at a 6 percent discount rate.

Table 1: Annualized Vessel Capital Cost at 6 percent Discount Rate

	Current Panamax	Neo Panamax
Vessel capacity (TEU)	4,000	12,000
Vessel purchase cost	$60,000,000	$120,000,000
Vessel life span (years)	30	30
Annual capital cost	**$4,358,935**	**$8,717,869**

It is important to note that these are rough order of magnitude estimates; vessel purchase prices can vary significantly depending on the number of vessels in the particular order, when the order is placed, etc. However, in general the purchase price of an NPX vessel is about twice that of a current Panamax vessel for about three times the capacity.

3 FUEL COST

Typically, the largest cost category for container ships is fuel. Main engines, auxiliary engines, and boilers all consume fuel at different rates depending on mode (at sea or at berth). Table 2 summarizes estimated total fuel consumption rates per day for both vessel sizes. Main and auxiliary engines are used at sea, while auxiliary engines and boilers are generally used at berth.

Table 2: Fuel Consumption per Day by Mode

	Current Panamax	Neo Panamax	
a	80%	80%	Main Engine Load Factor At-Sea
b	38,000	72,240	Average Main Engine Power Rating (kW)
c	24	24	Hours of Transit per Day
d = a*b*c	729,600	1,387,008	Energy per Day (kW-hr)
e	290	290	Specific Fuel Content (g/kWh)
f	1,000,000	1,000,000	Grams per Metric Ton
g = d*e/f	211.6	402.2	Main Engine Metric Tons of Fuel per Day at Sea
h	1,400	1,834	Auxiliary Engine Power Usage at Sea (kW)
i = c*e*h/f	9.7	12.8	Auxiliary Engine Metric Tons of Fuel per Day at Sea
j = g+i	**221**	**415**	**Total Fuel Consumption per Day at Sea (metric tons)**
k	1,300	2,445	Auxiliary Engine Power Usage at Berth (kW)
l = c*e*k/f	9.0	17.0	Auxiliary Engine Metric Tons of Fuel per Day at Berth
m	510	765	Boiler Power at Berth (kW)
n = c*e*m/f	3.5	5.3	Boiler Metric Tons of Fuel per Day at Berth
o = l+n	**12.6**	**22.3**	**Total Fuel Consumption per Day at Berth (metric tons)**

Overall, NPX vessels consumed about twice as much fuel as current Panamax vessels while providing about three times as much capacity, yielding higher fuel efficiency at capacity.

Table 3 summarizes the estimated annual fuel cost for both vessel sizes using the results from Table 2. Fuel cost per metric tons is estimated based on January 2012 rates for IFO380 from Bunkerworld.com; this value will vary significantly over time and is likely to continue to trend upward over time.

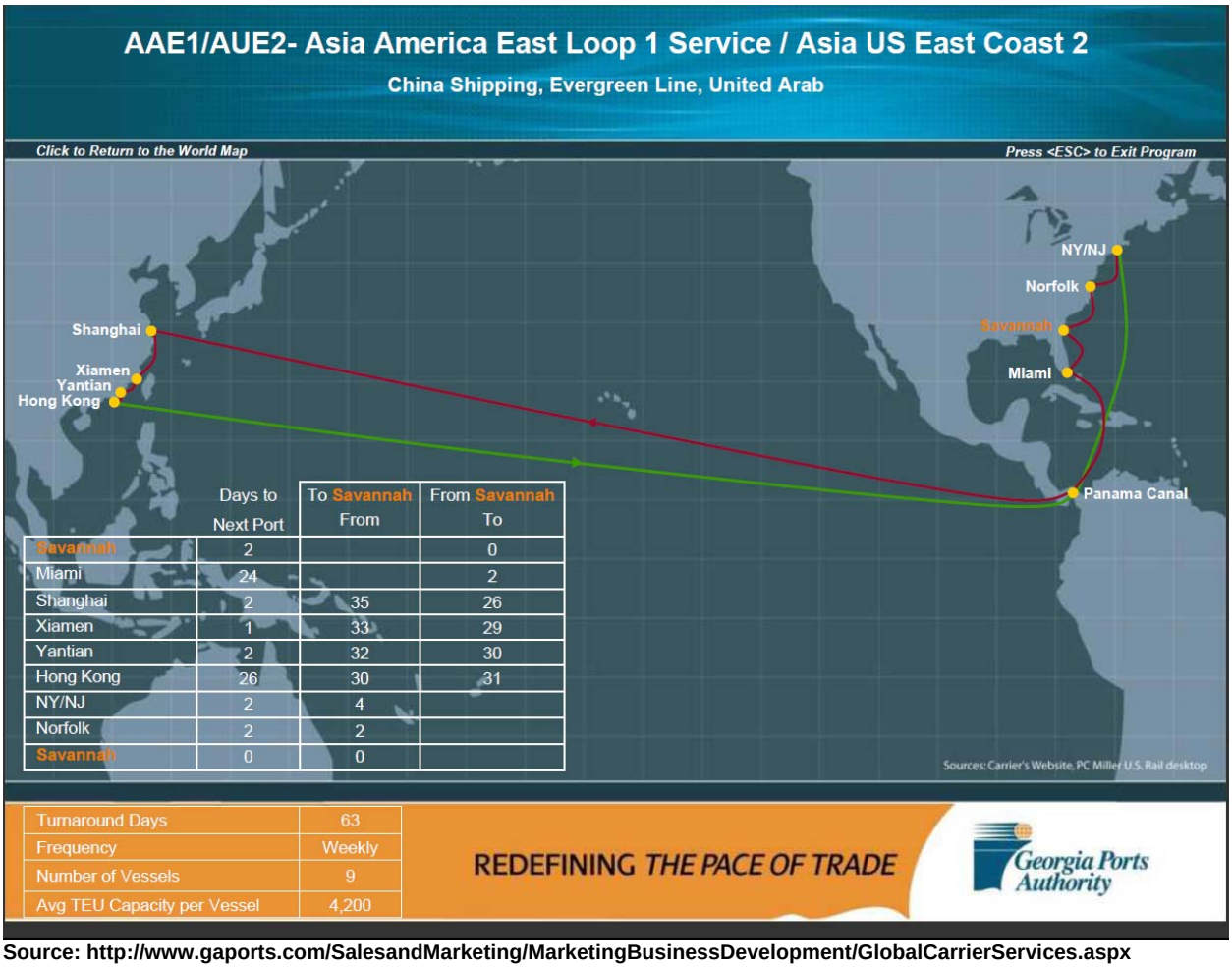
Table 3: Annual Fuel Cost

	Current Panamax	Neo Panamax
Operating speed (knots)	20	20
Fuel consumption per day at sea (metric tons)	221	415
Fuel consumption per day at berth (metric tons)	13	22
Fuel unit cost per metric ton	$700	$700
Fraction of time at sea (remainder at berth)	80%	80%
Days at sea per year	292	292
Days on berth per year	73	73
Fuel cost per year	**$45,883,000**	**$85,967,000**

Assuming the vessels are transiting identical voyages, NPX vessels will consume about twice as much fuel as current Panamax vessels.

An example vessel route from Asia to the US East Coast via the Panama Canal is shown in Figure 1 from the Port of Savannah, GA.

Figure 1: Vessel Route from China to the USEC via the Panama Canal



	Days to Next Port	To Savannah From	From Savannah To
Savannah	2		0
Miami	24		2
Shanghai	2	35	26
Xiamen	1	33	29
Yantian	2	32	30
Hong Kong	26	30	31
NY/NJ	2	4	
Norfolk	2	2	
Savannah	0	0	

Turnaround Days	63
Frequency	Weekly
Number of Vessels	9
Avg TEU Capacity per Vessel	4,200

Source: http://www.gaports.com/SalesandMarketing/MarketingBusinessDevelopment/GlobalCarrierServices.aspx

4 PANAMA CANAL TOLLS

Using the example route from Figure 1, Panama Canal tolls can be estimated based on published current canal toll rates. It is important to note that post-expansion toll rates have yet to be determined and will likely increase somewhat; however, current rates provide a reasonable idea of the order of magnitude of the costs expected. Table 4 summarizes the annual canal toll costs for both vessel sizes at 80 percent utilization, as well as the NPX vessel at a lower level of utilization.

Table 4: Panama Canal Tolls

	Current Panamax	Neo Panamax	Neo Panamax, lower utilization
Asia - USEC round trip time (days)	63	63	63
Annual trips per vessel	5.8	5.8	5.8
Panama Canal Toll per TEU (Containers on Vessel) *	$74.00	$74.00	$74.00
Panama Canal Toll per TEU (ballast) *	$65.60	$65.60	$65.60
Average Vessel Capacity Utilization	80%	80%	51%
Panama Canal Toll per passage	$289,280	$867,840	$835,584
Annual toll cost	**$3,351,975**	**$10,055,924**	**$9,682,164**

*** Source: http://www.pancanal.com/eng/maritime/tolls.html**

Containerships transiting the Panama Canal have to pay for both containers on the vessel, as well as additional tolls for unutilized capacity. Since tolls are charged on a per-TEU basis, large vessels do not offer improved cost-effectiveness for this particular category.

5 LABOR COST

Very little staffing is required for modern containerships and crew size is essentially fixed regardless of size. Table 5 summarizes estimated daily crew costs. For instance, the 15,000 TEU Emma Maersk and the 4,600 TEU MOL Encore both have a maximum crew capacity of 30, with normal staffing typically under half of that. AECOM estimates that both current Panamax and NPX sizes will require about 12 crew members.

Table 5: Annual Crew Cost

	Current Panamax	Neo Panamax
Vessel crew size (people)	12	12
Crew cost per person-day	$300	$300
Total vessel crew cost per day	$3,600	$3,600
Total vessel crew cost per year	**$1,314,000**	**$1,314,000**

Sources: http://www.emma-maersk.com/specification/; http://www.ship-technology.com/projects/mol_encore/

Large vessels have the advantage of transporting more cargo without requiring additional crew, leading to improved economies of scale in NPX vessels.

6 ANNUAL COST SUMMARY

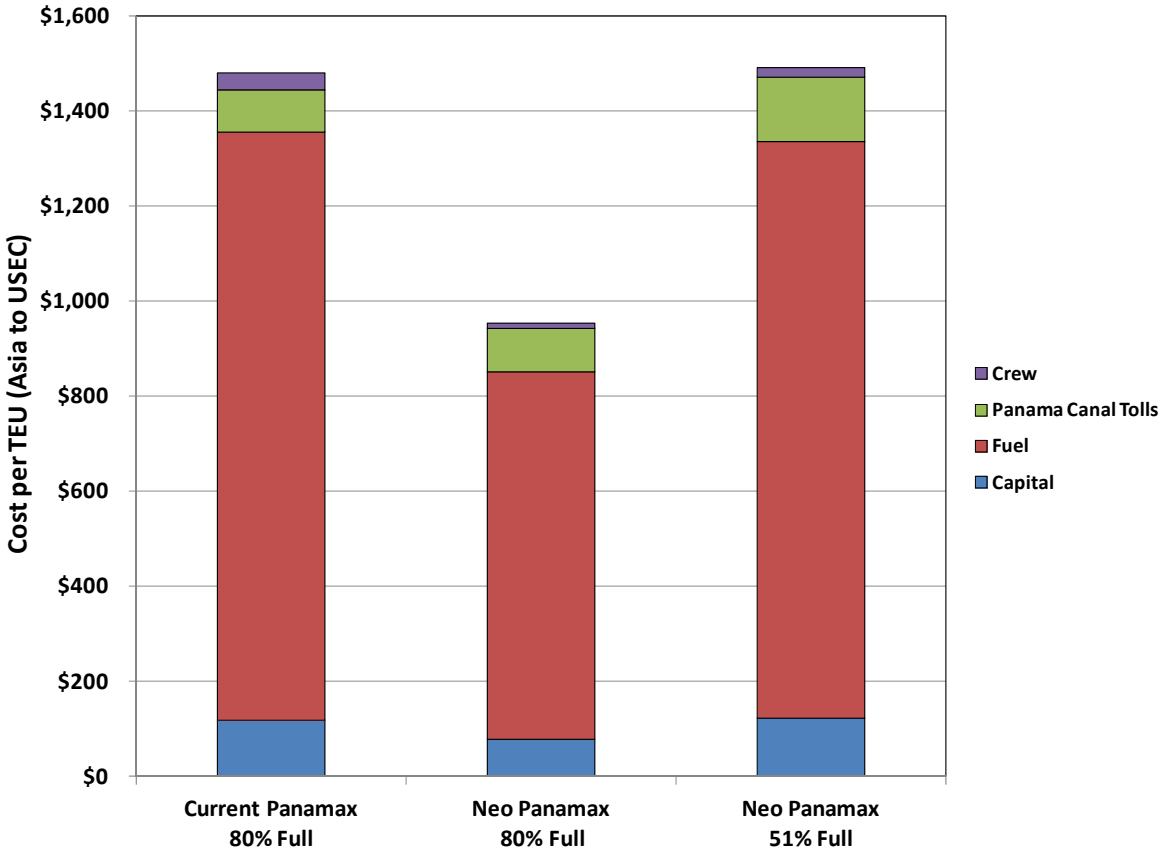
Table 6 is a summary of the total cost per year for both size vessels at 80 percent utilization, and an NPX vessel at 51 percent utilization.

Table 6: Total Annual Cost per TEU

	Current Panamax	Neo Panamax	Neo Panamax, lower utilization
Total vessel cost per year	**$54,908,090**	**$106,054,472**	**$105,715,752**
Vessel utilization	80%	80%	51%
TEU moved per round-trip voyage	6,400	19,200	12,240
Annual trips per vessel	5.8	5.8	5.8
TEU moved per year	37,079	111,238	70,914
Cost per TEU moved	**$1,481**	**$953**	**$1,491**

Assuming the vessels can achieve similar levels of utilization, NPX vessels are significantly more cost-effective than current Panamax vessels. An NPX vessel at 51 percent utilization has similar per-TEU costs as a current Panamax vessel at 80 percent utilization.
Figure 2 is a stacked bar chart comparing the total cost per TEU of both sizes of vessels.

Figure 2: Vessel Cost per TEU moved between Asia and US East Coast



7 IMPLICATIONS FOR US EAST COAST PORTS

Assuming there is market demand to sufficiently utilize the capacity of larger vessels, NPX vessels offer compelling cost advantages compared the much smaller current Panamax size. Particularly, larger vessels offer much better fuel-efficiencies, which dominate shipping lines' total operating expenditures. Figure 2 above also explains the popularity of "slow steaming" where vessel operators incur additional capital (i.e. buying an extra ship) and crew expense in order to run ships at a slower speed and save fuel.

While shipping lines will gradually transition to larger vessels where possible, pooling shipments into larger vessels will not be feasible for all markets. Table 7 compares the weekly vessel calls originating in Northeast Asia resulting from shipping rotations using both sizes of vessels for the Ports of Savannah and Wilmington. Table 7 also assumes that Wilmington will have about the same proportion of container moves in the northeast Asia trade lane as Savannah (37 percent).

AECOM estimates that, regardless of overall vessel utilization, a minimum of 25 percent of the cargo onboard will be discharged at a single US east coast port with the current Panamax vessel size. This is consistent with Figure 1 on page 3, which shows four US east coast calls in the vessel rotation of a 4,200 TEU vessel.

NPX vessels, however, will likely call at fewer ports due to constraints such as water depth; AECOM assumes in this case, up to 50 percent of container moves will be completed per call (i.e. two US east coast vessel calls per vessel voyage).

Table 7: Weekly Vessel Calls at East Coast Ports by Vessels from Northeast Asia

	Current Panamax 80% Full	Current Panamax 80% Full	Neo Panamax 80% Full	Neo Panamax 51% Full	Post Panamax 80% Full	
a	4,000	4,000	12,000	12,000	8,000	TEU Capacity
b	80%	80%	80%	51%	80%	Utilization
c = 2*a*b	6,400	6,400	19,200	12,240	12,800	TEU/Voyage (Discharge + Load)
d	25%	50%	50%	50%	25%	% of Vessel Discharge+Load
e = c*d	1,600	3,200	9,600	6,120	3,200	TEU/Call (Load+Unload)
f	20,737	20,737	20,737	20,737	20,737	2011 Weekly TEU at Savannah vie NE Asia
g = f/e	13.0	6.4	2.2	3.4	6.5	NE Asia Calls per Week at Savannah
h	2,047	2,047	2,047	2,047	2,047	2011 Weekly TEU at Wilmington via NE Asia
i = h/e	1.3	0.6	0.2	0.3	0.6	NE Asia Calls per Week at Wilmington
j	9,250	9,250	9,250	9,250	9,250	2040 Weekly TEU at Wilmington via NE Asia
k = j/e	5.7	2.9	<1.0	1.5	2.9	2040 NE Asia Calls per Week at Wilmington

Data sources: http://www.gaports.com/SalesandMarketing/MarketingBusinessDevelopment/GPABytheNumbers.aspx, http://www.ncports.com/_Port_Statistics.htm, *NC Maritime Market Scenario* technical memorandum

At current volumes, larger ports like Savannah are more likely to serve shipping lines with vessel rotations including 12,000 TEU vessels as they handle enough volume from a single region to justify the larger vessels; today's volumes at Savannah could support weekly calls by two to three Neo Panamax vessels if the Savannah Harbor were deep enough.

By contrast, with today's container volumes, Wilmington would require significantly less than a vessel call per week (0.3 vessel per week, or one vessel every three to four weeks) by NPX vessels serving the NE Asia trade lane. As a result, it is unlikely shipping lines would include Wilmington in their shipping rotation for Neo Panamax vessels in the near-term.

As container demand is projected to grow for Wilmington in the future, shipping lines would likely dedicate greater vessel capacity to this market; however, NPX vessels would still not appear to be the most economically viable alternative as compared to mobilizing those vessels to serve larger ports. Assuming that trade with NE Asia accounts for about 37 percent of future container volumes at Wilmington, weekly container throughput at Wilmington would grow to 9,250 TEU by 2040 (= 1.3 million TEU forecast for 2040 / 52 weeks x 37 percent). Based on a traditional rotation of Panamax vessels, up to six weekly calls would be required from NE Asia. A Post Panamax vessel (PPX) with 8,000 TEU capacity could serve this same rotation with three weekly calls. Only one weekly NPX call would be required to meet projected demand on this trade lane, which is not likely to offer the frequency demanded by shippers.

Even if Wilmington is dredged to allow any vessel to call, shipping lines calling at Wilmington will likely transition from current Panamax to one or more intermediate size vessels (6,000 TEU or 8,000 TEU) before they consider using NPX vessels.

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